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Landfill Temperature Sampling Interval Analysis

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LANDFILL TEMPERATURE SAMPLING INTERVAL ANALYSIS

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Landfill temperatures are known to be associated with refuse decomposition which results in settlement and gas production. It might be possible that a direct correlation can be drawn between landfill temperature and gas production, settlement and/or virus and microorganism survival. This study was undertaken to develop the best sampling interval for use with manual read-out temperature equipment.

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LANDFILL TEMPERATURE SAMPLING

INTERVAL ANALYSIS

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was prepared by
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U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Monitoring
Solid Waste Research
1971

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LANDFILL TEMPERATURE SAMPLING INTERVAL ANALYSIS

James A. Geyer, Chemical Engineer
and
Richard J. Wigh, Sanitary Engineer

Introduction

Landfill temperatures are known to be associated with refuse decomposition [3, 4] which results in settlement and gas production. It might be possible that a direct correlation can be drawn between landfill temperature and gas production, settlement and/or virus and microorganism survival. To study possible correlations, temperature measurements will be taken in test cells at the Division of Research and Development, Ultimate Disposal Branch's Boone County Research Facility.

Because of the expense of continuous monitoring and the long travel time to the research facility, a minimum number of measurements (i.e., maximum sampling intervals) is desirable. This study was undertaken to develop the best sampling interval for use with manual read-out temperature equipment.

The temperature data used to determine the optimum sampling interval was taken from a report entitled "Pollution of Subsurface Water by Sanitary Landfills"[1] by A. A. Fungaroli at Drexel University under PHS Grant Number 5-R01-UI-00516 (hereafter referred to as the Drexel report).

Background

The Drexel report was used because temperatures were recorded continuously on a daily basis. Other landfill investigators, such as Robert C. Merz[2], have recorded temperatures; but none have done it daily over such a long period of time. This report was also chosen because of the similarities in climate between the Boone County Research Facility and the Drexel Field Study at Chester County, Pennsylvania.

The Drexel report contains temperature data taken both from a laboratory scale landfill in a lysimeter and from a field test landfill installation. The data used were collected from September 27, 1967 to December 31, 1968 on the lysimeter and from March 10, 1968 to December 24, 1968 on the field site. The temperatures in the lysimeter were recorded above and below the refuse bed and at four different depths inside the bed (a total of six probes). Temperatures in the field sanitary landfill were recorded at a variety of locations and depths (total of 20 probes). Additional temperature probes were used but only those most applicable to the Ultimate Disposal Branch's research needs were studied.

Procedure

The main objective of this study was to check the accuracy of extended temperature sampling intervals using the Drexel data. A list of daily temperatures for each probe was made

and then subdivided into 3-, 7-, 14-, and 28-day sampling intervals. The mean, maximum, and minimum temperatures were calculated for all sampling intervals. A comparison was made between the daily figures and the extended interval figures (See example in Appendix).

The mean, maximum and minimum temperature values for each interval and each probe were plotted as temperature versus time (See example - Figure 1). Instrumental error ranges were added to each plot. These error ranges were based on instrumental error ranges of a YSI 42 SC Telethermometer* using YSI No. 401 probes*. The YSI 42 SC is one of the instruments to be used at the Boone County Research Facility. These error ranges were meant to provide a qualitative measure of the accuracy of the extended sampling interval. It was felt that an accurate interval would be when the extended interval data remained within this instrumental error range. The maximum allowable interval would be at that point when the data fell outside the error range.

Analysis of Results

Analysis was made of the plots to determine the percentage of extended sampling intervals in which the mean, maximum, and minimum temperatures were inside the instrumental error range (See Tables 1 and 2). The percentage figures for the

*Manufactured by Yellow Springs Instrument Company, Yellow Springs, Ohio.

SAMPLING INTERVAL ANALYSIS
EXAMPLE
DREXEL FIELD #7-4

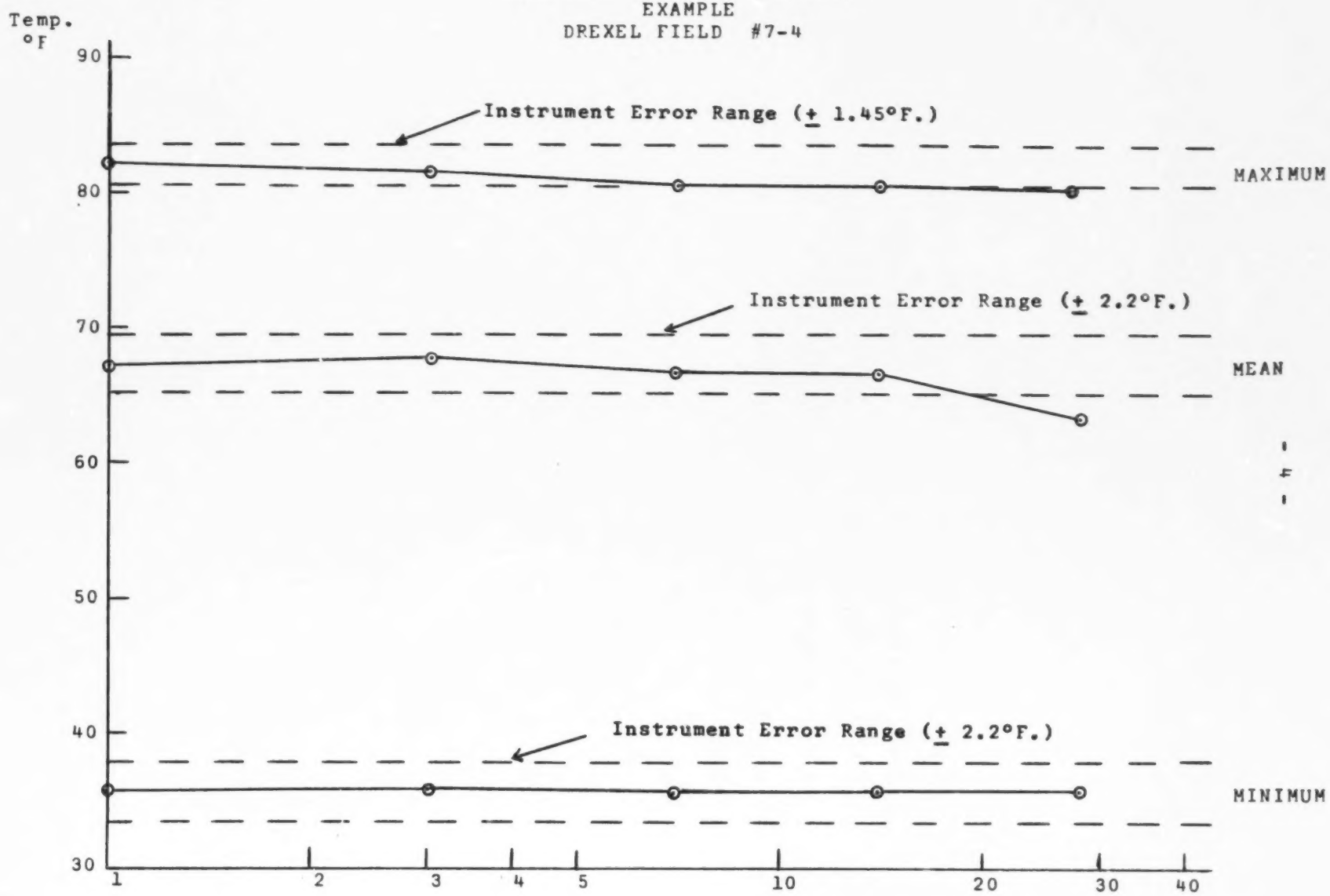

FIGURE 1

lysimeter (Table 1) were not too encouraging; but these figures are biased by the small number of probes used. Analysis of the field study (Table 2) using 20 probes showed excellent data reproduction on extended sampling intervals.

Conclusions

From the results in Tables 1 and 2, the best extended sampling interval would be three days. However, because of the small sample size of the lysimeter and the fact that it was on a laboratory scale, more emphasis should be placed on the field study which more closely approximates the studies that will be done at the Boone County Research Facility. The field study results (Table 2) show that sufficient accuracy can also be obtained for the 7- and 14-day intervals.

The recommended sampling interval to be used at the Boone County Research Facility will be 7 or 14 days. These intervals should be economical and provide reasonably accurate temperature data. However, some of the other parameters being monitored (e.g. moisture content) will initially require twice-a-week sampling. Therefore in the beginning, temperature will be recorded on a 3 1/2-day interval along with the other parameters being monitored.

Future Study

The establishment of two or more sampling intervals may be desirable if field data indicates significant temperature

variations in the early stages of decomposition followed by a long-term period of minor temperature fluctuations. This analysis should be revised as more data are compiled in the Drexel and Boone County Research Facility studies. A study could also be done on probe positions in a landfill for optimum temperature monitoring.

TABLE 1

Drexel Lysimeter
Percent Inside Error Range
Total Survey
Six Probes

Temperature	Sampling Interval (Days)	Percentage
Maximum	3	83.3
	7	33.3
	14	16.7
	28	0
Mean	3	100.0
	7	83.3
	14	83.3
	28	83.3
Minimum	3	50.0
	7	33.3
	14	33.3
	28	0

TABLE 2

Drexel Field
Percent Inside Error Range
20 Probes

Temperature	Sampling Interval (Days)	Percentage
Maximum	3	100.0
	7	95.0
	14	95.0
	28	80.0
Mean	3	100.0
	7	100.0
	14	100.0
	28	80.0
Minimum	3	100.0
	7	100.0
	14	100.0
	28	95.0

References

1. Fungaroli, A. A. Pollution of subsurface water by sanitary landfill. Drexel University, Feb. 1969. PHS Grant No. 5-R01-UI-00516.*

2. Gunnerson, Charles G. "Optimizing Sampling Intervals in Tidal Estuaries," Proceedings of the American Society of Civil Engineers. 92(SA2): 103-125, April 1966.

3. Merz, Robert C. and Ralph Stone. Special studies of a sanitary landfill. University of Southern California, March 15, 1969. PHS Research Grant No. UI-00518-08.*

4. Nedry, D. E. "Temperature is a Test of Composition." The American City, 69(3):29, March 1954.

*References 1 and 3 are pending publications of the Environmental Protection Agency. Loan copies are available from SWIRS, Office of Information, Solid Waste Management Office, EPA, 5600 Fishers Lane, Room 15B-17, Rockville, Maryland 20852

Appendix

Sampling Interval Analysis Example
Drexel Field # T-4

Date	1-Day	3-Day	7-Day	14-Day	28-Day
5/16	59.0	59.0	59.0	59.0	59.0
5/17	59.0				
5/18	60.9				
5/19	60.9	60.9			
5/20	63.4				
5/21	62.9				
5/22	62.5	62.5			
5/23	62.5		62.5		
5/24	62.3				
5/25	62.2	62.2			
5/26	62.2				
5/27	63.1				
5/28	62.8	62.8			
5/29	61.1				
5/30	60.8		60.8	60.8	
5/31	61.9	61.9			
6/1	62.5				
6/2	62.5				
6/3	63.7	63.7			
6/4	64.6				

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
6/5	64.9				
6/6	65.4	65.4	65.4		
6/7	65.9				
6/8	68.3				
6/9	--	--			
6/10	70.8				
6/11	71.8				
6/12	71.6	71.6			
6/13	71.0		71.0	71.0	71.0
6/14	70.5				
6/15	70.2	70.2			
6/16	70.2				
6/17	70.6				
6/18	70.7	70.7			
6/19	70.2				
6/20	70.4		70.4		
6/21	69.4	69.4			
6/22	69.4				
6/23	69.4				
6/24	71.0	71.0			
6/25	71.6				
6/26	72.9				

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
6/27	73.7	73.7	73.7	73.7	
6/28	73.4				
6/29	71.3				
6/30	71.3	71.3			
7/1	71.7				
7/2	73.7				
7/3	75.0	75.0			
7/4	75.0		75.0		
7/5	74.6				
7/6	74.7	74.7			
7/7	74.7				
7/8	74.7				
7/9	75.1	75.1			
7/10	75.5				
7/11	76.0		76.0	76.0	76.0
7/12	76.1	76.1			
7/13	76.0				
7/14	76.0				
7/15	77.4	77.4			
7/16	77.8				
7/17	78.2				
7/18	79.1	79.1	79.1		

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
7/19	80.3				
7/20	80.4				
7/21	79.9	79.9			
7/22	79.4				
7/23	79.3				
7/24	79.7	79.7			
7/25	79.6		79.6	79.6	
7/26	79.5				
7/27	79.4	79.4			
7/28	79.3				
7/29	79.2				
7/30	79.1	79.1			
7/31	78.4				
8/1	78.3		78.3		
8/2	78.5	78.5			
8/3	79.0				
8/4	79.0				
8/5	79.1	79.1			
8/6	79.5				
8/7	79.2				
8/8	80.2	80.2	80.2	80.2	80.2
8/9	80.8				

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
8/10	80.8				
8/11	81.5	81.5			
8/12	80.8				
8/13	80.4				
8/14	79.7	79.7			
8/15	79.6		79.6		
8/16	79.6				
8/17	79.5	79.5			
8/18	79.6				
8/19	80.2				
8/20	80.1	80.1			
8/21	80.3				
8/22	80.5		80.5	80.5	
8/23	81.3	81.3			
8/24	82.1				
8/25	--*				
8/26	66.1	66.1			
8/27	66.2				
8/28	80.6				
8/29	79.0	79.0	79.0		

* No reading on that date.

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
8/30	58.9**				
8/31	68.1**				
9/1	77.7	77.7			
9/2	77.2				
9/3	76.8				
9/4	76.6	76.6			
9/5	76.6		76.6	76.6	76.6
9/6	76.8				
9/7	76.5	76.5			
9/8	75.7				
9/9	75.2				
9/10	75.0	75.0			
9/11	75.0				
9/12	64.5**		64.5		
9/13	73.8	73.8			
9/14	72.5				
9/15	71.7				
9/16	71.2	71.2			
9/17	71.2				
9/18	71.4				
9/19	71.3	71.3	71.3	71.3	

**Readings that were assumed erroneous.

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
9/20	71.2				
9/21	71.2				
9/22	71.6	71.6			
9/23	72.1				
9/24	62.9				
9/25	73.0	73.0			
9/26	73.9		73.9		
9/27	--				
9/28	74.5	74.5			
9/29	63.8				
9/30	72.4				
10/1	72.2	72.2			
10/2	71.1				
10/3	71.3		71.3	71.3	71.3
10/4	71.4	71.4			
10/5	70.1				
10/6	68.1				
10/7	67.8	67.8			
10/8	66.9				
10/9	66.0				
10/10	65.2	65.2	65.2		
10/11	65.2				
10/12	64.2				

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
10/13	--	--			
10/14	--				
10/15	--				
10/16	--	--			
10/17	64.3		64.3	64.3	
10/18	64.2				
10/19	64.6	64.6			
10/20	65.3				
10/21	65.0				
10/22	63.5	63.5			
10/23	61.9				
10/24	61.9		61.9		
10/25	61.2	61.2			
10/26	61.0				
10/27	61.0				
10/28	57.6	57.6			
10/29	56.6				
10/30	56.4				
10/31	56.4	56.4	56.4	56.4	56.4
11/1	42.6				
11/2	--				
11/3	--	--			

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
11/4	--				
11/5	--				
11/6	--	--			
11/7	--		--		
11/8	--				
11/9	--	--			
11/10	--				
11/11	--				
11/12	--	--			
11/13	--				
11/14	--		--	--	
11/15	--	--			
11/16	--				
11/17	--				
11/18	--	--			
11/19	--				
11/20	--				
11/21	46.2	46.2	46.2		
11/22	44.9				
11/23	43.7				
11/24	43.4	43.4			
11/25	43.5				

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
11/26	44.1				
11/27	43.9	43.9			
11/28	43.8		43.8	43.8	43.8
11/29	44.6				
11/30	46.0	46.0			
12/1	46.0				
12/2	45.3				
12/3	44.9	44.9			
12/4	44.9				
12/5	--		--		
12/6	--	--			
12/7	--				
12/8	--				
12/9	--	--			
12/10	--				
12/11	--				
12/12	--	--	--	--	
12/13	--				
12/14	38.1				
12/15	--	--			
12/16	37.0				
12/17	36.8				

Appendix (continued)

Date	1-Day	3-Day	7-Day	14-Day	28-Day
12/18	36.7	36.7			
12/19	36.3		36.3		
12/20	36.3				
12/21	36.1	36.1			
12/22	36.0				
12/23	35.9				
12/24	35.9	35.9			
12/25	--				
12/26	35.7		35.7	35.7	35.7
12/27					
12/28					
12/29					
12/30					
12/31					
Total	12,652.3	4211.0	1937.5	1000.2	570.0
Number	188	62	29	15	9
Mean	67.3	67.9	66.8	66.7	63.3
Maximum	82.1	81.5	80.5	80.5	80.2
Minimum	35.7	35.9	35.7	35.7	35.7

μσ *72-1-06s*